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Comments
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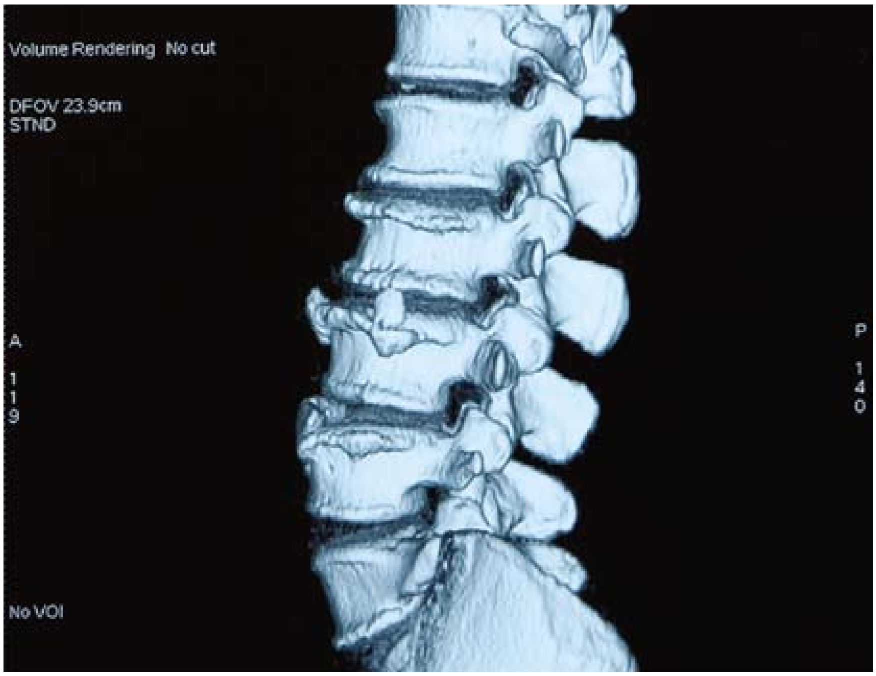
The Effectiveness of Active and Traditional Teaching Techniques in the Orthopedic Assessment Laboratory

By Sara Nottingham and Susan Verscheure

Active learning is a teaching methodology with a focus on student-centered learning that engages students in the educational process. This study implemented active learning techniques in an orthopedic assessment laboratory, and the effects of these teaching methods were evaluated in comparison to traditional teaching techniques. Mean scores from written exams, practical exams, and final course evaluations were compared for 79 human physiology students. One- and two-way analyses of variance were used to evaluate the effect of teaching methodology on test scores and evaluation responses. No significant differences were found for course evaluation responses and written and practical exam scores between the two learning groups. This study suggests that students can be equally successful in well-constructed active and traditional orthopedic assessment laboratories.



Computerized tomography of a lumbar spine.

Research on active learning has greatly increased over the past several years; however, one area of active learning that has been minimally explored is its application to the laboratory setting, specifically orthopedic assessment. Although active learning has been defined in many ways, it essentially consists of instructional methods that emphasize student engagement in the learning process (Page, Thomas, and Marshall 1977; *Random House Webster's College Dictionary* 1998). In an active learning environment, students may be expected to complete preparatory assignments, participate in class discussions, teach other students, and focus class time on critical thinking, among other activities.

Research of learning and instructional techniques in the collegiate setting have been bolstered in recent years in response to an increase in university science students, student evaluations, and educational reform (Lawrenz, Huffman, and Appeldoorn 2005; NRC 2000; Walczyk and Ramsey 2003). Although active learning has been observed in a variety of classroom settings, instructional strategies in the psychomotor domain are seldom addressed (Chung and Chow 2004; Jones-Wilson 2005; Michael 2006; Taraban et al. 2007). Psychomotor skills require an interaction between the brain and motor activity, uniting cognitive processing and the application of knowledge (Dechsri, Jones, and Heikkinen 1997; Michael and Modell 2003; Page, Thomas, and Marshall 1977; *Random House Webster's College Dictionary* 1998). Psychomotor activity is a significant aspect of athletic training and physical therapy education, especially in the laboratory and clinical settings. Researchers in these areas have explored learning styles (Coker 2000; Gould and Caswell 2006), peer-assisted learning (Henning, Weidner, and Jones 2006), pedagogic strategies (Mensch and Ennis 2002), and active learning (Berry, Miller, and Berry 2004), but research is limited. With the increase in athletic training and physical therapy programs, and the significant role of the laboratory setting in these professions, there is a need to explore effective teaching methodologies specific to this environment.

The purpose of this study was to explore the effectiveness of active learning techniques implemented in an introductory orthopedic assessment laboratory. Student success on written and practical examinations was compared between students enrolled in active and traditional laboratory settings. Additionally, we were interested in student perceptions of the learning environment, observed by responses in a final course evaluation.

Methods

Subjects

A total of 97 students completed the orthopedic assessment laboratory course used for this study. On the last day of class (week 10), students were informed of the research study and asked to participate. The primary investigator delivered the research introduction and consent forms to each lab section to ensure uniformity of instructions. Students were asked to complete the course evaluation, and if they were interested in participating in the study, they could sign the consent and data acquisition forms to approve the use of their course grades and evaluation responses. It was made clear that all information from questionnaires and tests would be coded for subject confidentiality.

To be included in this study, students had to be enrolled in this course throughout the term and must have passed human anatomy. Students who were repeating the course, had experienced more than 30 hours of work or job shadowing in the orthopedic-assessment setting, or were concurrently enrolled in an athletic training practicum course were excluded from the study. A total of 79 students (24 male, 55 female) met the inclusion criteria and chose to participate. Five students were not eligible to participate because of incomplete information (missing test scores), and 13 students did not give consent. Subject demographics are described according to group in Table 1.

Instructors

Nine graduate certified athletic trainers (3 male, 6 female) acted as volunteer instructors for the laboratory courses. Each instructor was a Board of Certification certified athletic trainer and graduate student enrolled at the same university. Instructors had between zero and two years of teaching experience before teaching this course; however, all instructors had recently participated in a 10-week graduate course on teaching college science. Before the study began, instructors signed the consent form and underwent a casual interview with the primary investigator regarding their perceived teaching philosophy. This interview was designed to determine which teaching group the instructor would fit into best. According to their answers, discussion with the primary investigator, and their availability for teaching, instructors were assigned to the active or traditional learning group. Four lab sec-

TABLE 1

Subject demographics.

	Active group	Traditional group	Total
Demographic variable	***n***	***n***	***n***
Number of subjects	41	38	79
Sex			
Male	14	10	24
Female	27	28	55
Academic year			
Junior	2	2	4
Senior	39	36	75
Academic major			
Human physiology	38	38	76
General science/biology	2	0	2
Other	1	0	1

tions (two in each treatment group) were team taught by two instructors. The remaining two lab sections (one in each group) were taught solely by the primary investigator.

Setting

An upper-division, human physiology course required for graduation in the human physiology department provided the setting for this study. This course included a three-unit lecture portion with a one-unit laboratory section. The laboratory portion of the course provided the hands-on educational component of injury evaluation, palpation, history, and assessment of orthopedic injuries. The laboratory portion, which was the focus of this study, was held for one hour and 50 minutes each week of the 10-week term, plus finals week. Laboratory sections each contained 15–18 students.

Procedures

The university's Institutional Review Board approved this study before data collection began. A quasi-experimental, pretest/posttest comparison group design was used for this experiment. The instructors were told that the study was investigating different teaching techniques and that they would teach a particular group, but they did not know the details of the study beyond the techniques they were instructed to use. To limit instructor bias, groups were referred to as Group A and Group B throughout the term. Both groups utilized the same textbook and course content sheets, and most communication, posting of grades, assignments, and announcements were done using an Internet hub (Blackboard Academic Suite, version 7.0). Each lab section had a different version of the Blackboard website to allow for the dissemination of course materials.

Teaching methodology

After assignment to a lab category, each instructor was trained on the appropriate teaching methodology and procedures for their group. Specific lesson plans describing the class activities were given for each lab topic. Lesson plans included a detailed outline of the content to be addressed, particular concepts and examples to share with students, and tips for teaching the specific materials for that day. Instructors attended a one-hour meeting each week that included review of the lesson plans, clarification of questions and concerns, and reflection on their adherence to the protocol. Instructors were encouraged to share their thoughts about the lesson plans and protocols, both positive and negative, to ensure that the treatment was consistent between classes. Instructors were continually reminded of the importance of following the protocol, and there were no instances in which instructors reported difficulty in following the lesson plans.

As a part of the active teaching methodology, instructors expressed that the responsibility of the student in their own learning experience would be an important component of the class. Assignments were given to the active group as preparatory work, allowing students to increase their background knowledge on a topic before it was discussed in class. Conversely, the traditional group received assignments that acted as a follow-up for the information discussed. Grading rubrics were used for all assignments to increase consistency in assessment. As part of class preparation, students in the active group were expected to present a practical skill to the class during each session, and instructors provided immediate and constructive feedback. Students in the traditional group received demonstrations of all practical skills by instructors. Instructors in the active learning group focused on questioning students on their reasoning for performing skills and practical application, whereas instructors in the traditional group had a more passive role, serving as a resource if requested by students.

The instructional protocol also included the creation of a relaxed, welcoming environment for student questions and comments for both groups. Students in the active group were expected to interact with instructors and peers throughout the class session and were required to switch lab partners each week. Student interaction in the traditional group was encouraged; however, it was not the focal point of classroom instruction and students could have the same lab partners for the duration of the term. Students in both groups also had the opportunity to provide feedback to their instructors regarding the positive and negative qualities of the course at the midterm examination. Responses were discussed with students in the active group and considered as alterations to instructional methods, although no significant changes were made. Students in the traditional group were told by instructors that their comments would be considered in the development of the following year's class. Additional details regarding the differences between teaching groups are represented in Table 2.

Measures

Student knowledge of course material was assessed using a combination of written and practical examinations. These exams evaluated student knowledge of terminology, anatomical structures, and the critical un-

TABLE 2

Teaching methodology of active and traditional teaching groups.

Active group	Traditional group
Preparatory assignments	Follow-up assignments
Student presentation of practical skills	Instructor presentation of practical skills
Outside of class learning	In-class learning
First exposure to information is before class	First exposure to information is in class
Class time for critical thinking and application	Class time for learning and practicing skills
Active participation and involvement	Passive participation, voluntary interaction
Student responsibility for learning	Instructor responsibility for sharing information
Sharing teaching methodology and theory with students	Not sharing reasoning behind teaching methodology with students
Perceptive to what challenges students	Emphasis on giving information without consciously challenging students
Prompt, constructive feedback on in-class activities and assignments	Feedback provided at request of students in class, feedback provided on assignments
Inquiry-based discussion and discovery	Providing information to students during discussion
Emphasis on aligning instructional and assessment techniques	Instruction and assessment given to cover material without particular methodology
Students required to work with classmates and communicate with instructor	Students allowed to work individually and communicate minimally with instructor
Student feedback utilized throughout term	Student feedback utilized for following year's class

derstanding of special tests and the injury evaluation process. To establish the baseline knowledge of each group, all students were given a written multiple-choice and short-answer pretest on the first day of class. This exam was used to identify any differences between the treatment and comparison groups and also acted as a baseline of comparison for the post-test results. This test did not count toward the students' course grade. The pretest also reflected the design of the written and final examinations that the students were given later in the term.

The written midterm examination was given during week 5, and the written final examination was given during week 10. Each written exam contained five multiple-choice questions testing didactic information, five multiple-choice questions testing application of knowledge to scenarios, and three to five short-answer questions of varying length. The final exam contained cumulative content from the entire term, with equal amounts of information on topics learned before and after the midterm.

Practical exams were given during week 5 and during finals week of the term. These exams evaluated student ability to perform practical skills as a part of the injury evaluation process. The practical examinations contained five anatomical palpation questions, two range-of-motion tests, three special tests, and identification of the dermatome and myotome of one nerve root. The final examination also included a concussion evaluation question. Students were expected to perform tests properly, identify which structure(s) they were evaluating, and state the positive signs and implications of each test. Performance on each test question was graded on a point scale, and all instructors utilized the same grading rubric.

Students were also asked to reflect on their opinion of the quality of the learning environment with a course evaluation given during week 10. This was attached to the consent and data acquisition forms, so students were given 30 minutes to review and complete this information. The questionnaire contained 7 demographic and informational questions and 20 4-point Likert scale–type questions. Seven Likert-scale questions specific to teaching methodology were analyzed for this experiment. Five graduate athletic trainers who previously taught the course validated the survey to make sure questions were clear and applicable to the laboratory.

TABLE 3

Descriptive statistics for exam scores by learning group (%).

	Active group		Traditional group		Total	
Demographic variable	***M***	***SD***	***M***	***SD***	***M***	***SD***
Written exam score						
Pretest	39.96	11.20	43.23	10.36	41.53	10.86
Midterm	85.98	8.49	86.65	9.20	86.30	8.79
Final	88.49	10.71	86.83	10.81	87.70	10.72
Practical exam score						
Midterm	92.36	6.22	90.83	9.23	91.62	7.80
Final	92.78	5.56	93.08	6.19	92.92	5.84

Data analysis

Instructors of each lab section collected data throughout the term in the form of exam grades and course evaluations. Data were coded by teaching group and analyzed after laboratory instruction had ceased. For the written and practical exam data, a two-way, mixed effects analysis of variance (ANOVA) was used, with one between-subjects effect of teaching group and one within-subjects effect of time. The teaching group contained two levels, the active group (Group A) and the traditional group (Group B). The within-subjects effect of time for the written exam had three levels: the pretest, midterm, and final exams. The effect of time for the practical exam had two levels, which included the midterm and final exams. The dependent variable was the test score, measured on a percentage scale out of 100%. A one-way ANOVA was used to examine the Likert-scale course evaluation questions. The between-subject, independent variable was the teaching group, and the dependent variable was the total response score out of 28 points. A one-way ANOVA was also used to compare the responses to each individual course evaluation question. The alpha level was set at $\alpha = .05$ for all analyses. The Mauchly's Test of Sphericity was used with the analysis of the written exam scores, which was found to be untenable, $\chi^2(2) = 7.81$, $p < .05$. A Greenhouse-Geisser correction was used to adjust the p value. A post-hoc power analysis was performed, resulting in a power of .24 for the interaction effect. This sample size produced a power adequate for detecting a small effect (Faul et al. 2007). Data were analyzed using the SPSS Statistical Package (Version 16.0, 2007; SPSS Inc., Chicago, Illinois).

Results

Students in the active and traditional teaching groups did not perform differently on written exams throughout the term, $F(2, 154) = 1.32$, $p = .259$. When analyzed further, we discovered that teaching group did not have an effect on written exam score, $F(1, 77) = 0.26$, $p = .615$, but students did significantly improve on the exam scores over time, $F(2, 154) = 615.73$, $p < .001$. The Bonferroni procedure was used to control Family-Wise Type I error for the pairwise comparisons of the written exam scores over time. This revealed that both groups improved dramatically from the pretest to the midterm and final exams, as the pretest mean ($M = 41.53\%$) was sig-

FIGURE 1

Written exam scores by group.

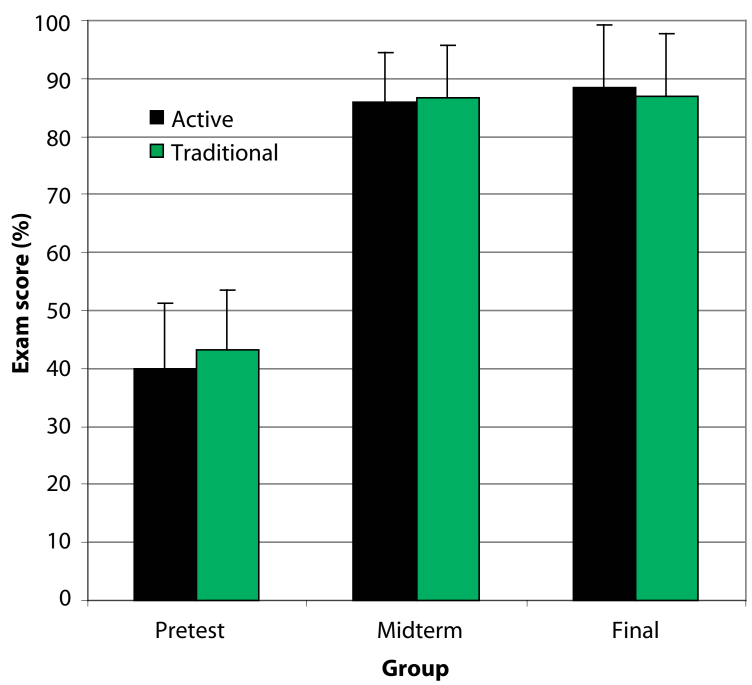


FIGURE 2

Practical exam scores by group.

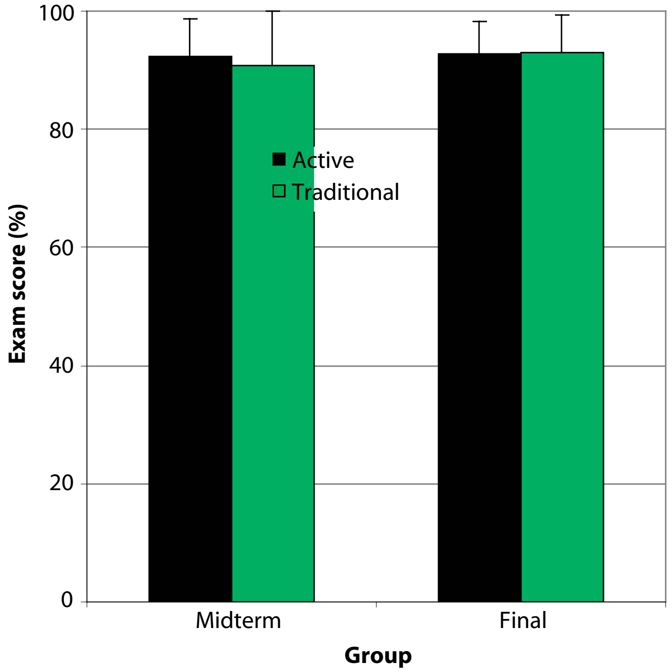
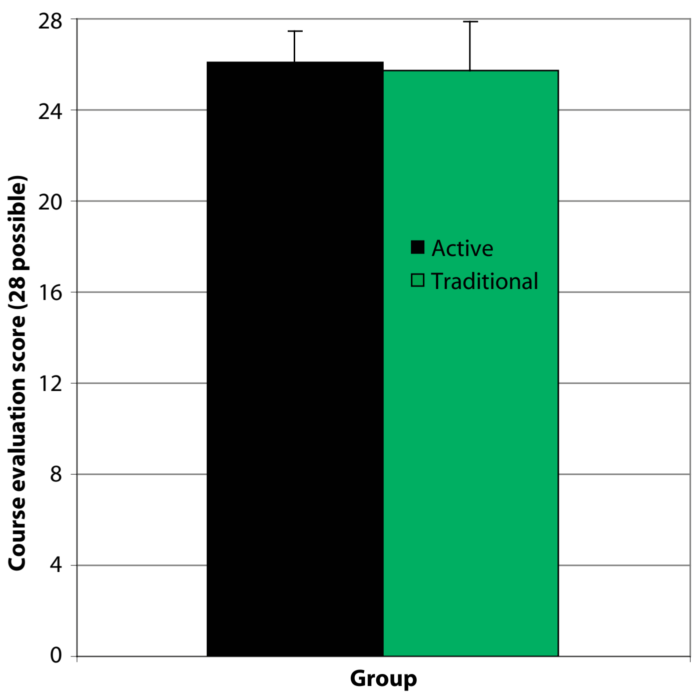


FIGURE 3

Course evaluation responses by group.



nificantly lower than the midterm (M = 86.30%) and final exam (M = 87.70%) means (p < .05). Students did not perform differently on the midterm and final exams (p > .05). Descriptive statistics for exam scores are shown in Table 3, and ANOVA results for the written exams can be found in Figure 1.

Similar to the written exams, students in different groups performed comparably on practical midterm and final exams, $F(1, 77) = 0.927$, $p = .339$. Group classification did not have an effect on exam score, $F(1, 77) = 0.247$, $p = .620$, and students performed similarly on the midterm (91.62%) and final (92.92%) practical exams, $F(1, 77) = 1.961$, $p = .165$ (see Figure 2).

Cumulative responses to the Likert-scale course evaluation questions were also similar between groups, $F(1, 77) = 0.698$, $p > .05$. There were no significant differences between responses for each of the individual questions answered, including Question #1, $F(1, 77) = 0.005$, $p = .944$; Question #2, $F(1, 77) = 2.113$, $p = .150$; Question #3, $F(1, 77) = .239$, $p = .626$; Question #4, $F(1, 77) = 1.109$, $p = .296$; Question #5, $F(1, 77) = 2.645$, $p = .108$; Question #6, $F(1, 77) = 3.150$, $p = .080$; and Question #7, $F(1, 77) = 0.183$, $p = .670$. Descriptive statistics for course evaluation responses by question are displayed in Table 4, and the means are illustrated in Figure 3.

Discussion

Results of our study indicate that students in active and traditional learning environments do not perform differently on written and practical knowledge of orthopedic assessment. The high final exam scores (written = 87.7%, practical = 92.9%) and course evaluation responses (25.9 out of 28) suggest that effective teaching

TABLE 4

Descriptive statistics for course evaluation questions relating to teaching methodology by learning group.

	Active group		Traditional group		Total	
Question	*M**	*SD*	*M**	*SD*	*M**	*SD*
#1: The instructors provided constructive feedback regarding my learning progress and skills when needed.	3.56	0.50	3.55	0.56	3.56	0.53
#2: The instructors' feedback on my learning progress was valuable.	3.49	0.50	3.66	0.53	3.57	0.52
#3: The instructors were knowledgeable about the course content area.	3.85	0.42	3.89	0.31	3.87	0.37
#4: The instructors were patient with students.	3.93	0.26	3.84	0.44	3.89	0.36
#5: A variety of instructional approaches/strategies were used to present course material.	3.51	0.60	3.26	0.76	3.39	0.69
#6: The instructors encouraged me to participate in this class.	3.93	0.26	3.79	0.41	3.86	0.35
#7: The lab instructors were effective in teaching the subject matter.	3.80	0.40	3.84	0.37	3.82	0.38
Total†	26.07	1.40	25.74	2.13	25.91	1.78

Note: *1 = *strongly disagree;* 4 = *strongly agree.* † Score of 28 possible.

occurred in both groups. The means for each individual course evaluation question were also very similar, demonstrating no significant differences between groups in terms of instructor feedback, knowledge, patience, instruction, and overall effectiveness. Similar scores and responses between groups could be attributed to a lack of differences in teaching methodology between the groups. Several teaching techniques known to promote student learning were used in both groups, including hands-on activities, outside-of-class learning, and communication with instructors and peers (Bain 2004; Walker 2003). Similarly, teaching and learning techniques used in and out of class were diverse, allowing students with a variety of learning styles to interact with the content (Henning, Weidner, and Jones 2004). The instructors who taught the courses had minimal teaching experience before this course, possibly making it more difficult to follow the lesson plans and facilitate the class. Even though most labs were team taught to help instructors follow the researchers' instructions, there was no external evaluator present to assess the instructors' ability to utilize the lesson plans as designed. Therefore, there could have been issues in both groups relating to the actual execution of the teaching methodology.

Our findings are consistent with other authors, who found no difference in knowledge gained in an active learning classroom in comparison to traditional learning (Dollman 2005; Love et al. 1989; Haidet et al. 2004). In contrast to our results, researchers in chemistry, physiology, and biology have found increases in student achievement and enjoyment of the active learning classroom in comparison to traditional teaching methods (Taraban et al. 2007; Dechsri, Jones, and Heikkinen 1997; Ford, Mazzone, and Taylor 2005). Taraban et al. (2007) found that students who participated in activities that included guided inquiry and role playing performed better on factual recall and conceptual laboratory activities than traditional learning students. These students also felt like they learned more in this setting (Taraban et al. 2007). Studies of active learning in the psychomotor domain, such as nursing and physical therapy, have also demonstrated positive outcomes with active learning techniques (Ford, Mazzone, and Taylor 2005; Jeffries, Rew, and Cramer 2002). Nursing students who underwent interactive group activities were more satisfied with their learning experience than those who learned practical skills through traditional lecture (Jeffries, Rew, and Cramer 2002). Other researchers discovered that although students improved or performed similarly on exams, students did not enjoy the active learning environment (Haidet et al. 2004; Lake 2001).

These divergent findings regarding active and traditional teaching techniques allude to the challenges of measuring significant learning experiences. Several authors described that much of active learning is based on reaching long-term conceptual goals, such as teaching students how to learn, communicate with others, develop new interests and values, and apply knowledge and skills (Bain 2004; Fink 2003; Weimer 2002). These authors also emphasized the importance of aligning assessment with these learning goals, which may be impossible over one academic term. The examinations in our study were the same for both groups, which did not accurately assess the more conceptual goals of the active learning group. To successfully facilitate active learning, the examinations could have required more critical thinking and integration of information and less factual recall. Unfortunately, different examinations could not be utilized in the specific application of this research design, a limitation of this study. The material in this laboratory course was very concrete and memory based, with minimal abstract knowledge. In addition, students were highly motivated to succeed in the course, with many of them planning to pursue graduate studies in medicine, physical therapy, nursing, and other related health professions. The straightforward nature of the course content and the student desire to succeed provided less room for variation between the lab groups, which could have attributed to the minor differences found between them.

Active learning has been supported by several authors and researchers as an effective method for increasing student reliance, confidence, communication, and responsibility, among other characteristics (Bain 2004; Fink 2003; Michael 2006; Weimer 2002). Current research has suggested that students who participate in active learning environments do just as well as students who learn in the traditional learning environment. With these results, instructors might consider implementing active learning techniques in their lecture and laboratory classrooms, without fear of hampering student success or enjoyment. Regardless of the potential benefit of using active learning, students, teachers, and academic institutions are often resistant to changes in teaching methodology. Shifting to more student-centered teaching usually creates more work for instructors and students, and the change may feel uncomfortable and threatening (Weimer 2002). Despite the challenges, we recommend that educators gradually alter their teaching with the hopes of reaching the long-term goals of active learning. Some authors have suggested that slowly introducing active learning techniques may be more successful than making dramatic changes, as it allows students and instructors to adjust (Fink 2003; Lake 2001). Our study revealed that students in the active learning group performed just as well as those in the traditional learning group, providing an encouraging step toward more research of active learning in athletic training, physical therapy, and other similar laboratory settings.

Limitations and suggestions for future research

There are some limitations present in this study that may minimize its application to different settings. This course was taught by athletic trainers who based class discussion and examples on their experiences. The subject pool used consisted of a convenience sample of human physiology students who, for the most part, were not intending to pursue a career in athletic training. This may have affected their interest in the course. With the primary investigator as an instructor, bias was also present in the overall design and execution of the study. To minimize this bias, the primary investigator taught one of each lab group and closely followed the lesson plans to be consistent with other instructors. Consistency in the execution of the teaching methodology may also have been affected by the large number of instructors teaching the lab sections. Variations most likely occurred between laboratories because of the differences in instructors and their enthusiasm, personality, and interaction with the students in their lab section.

On the basis of our experiences, we encourage future researchers to explore the use of active learning techniques with students in both the lecture and laboratory classrooms. Studies that assess student learning over lengthier time periods may increase our knowledge of the long-term effects of active learning. Specifically, active learning could potentially generate professionals who are more confident, self-reliant, and better communicators and take responsibility for their own learning. We faced challenges in assessing these important characteristics of active teaching. Collaborating with social scientists and psychologists in the development of student assessment of these skills across their degree program could provide valuable information regarding this aspect of student learning. ■

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